

Rejuvenation of Spent Media via Supported Emulsion Liquid Membranes

FINAL REPORT

Principal Investigator

John M. Wiencek
The University of Iowa
Chemical & Biochemical Engineering
Iowa City, Iowa 52242

Funded Period

March 1, 1999 – November 30, 2002

NASA Grant Number

NAG8 – 1588

Project Objective

The overall goal of this project is to maximize the reuseability of spent fermentation media. Supported emulsion liquid membrane separation, a highly efficient extraction technique, is used to remove inhibitory byproducts during fermentation; thus, improving the yield while reducing the need for fresh water. The key objectives of this study are:

- * Develop an emulsion liquid membrane system targeting low molecular weight organic acids which has minimal toxicity on a variety of microbial systems.
- * Conduct mass transfer studies to allow proper modeling and design of a supported emulsion liquid membrane system.
- * Investigate the effect of gravity on emulsion coalescence within the membrane unit.
- * Assess the effect of water re-use on fermentation yields in a model microbial system.
- * Develop a perfusion-type fermentor utilizing a supported emulsion liquid membrane system to control inhibitory fermentation byproducts.

Work for the coming year will focus on the determination of toxicity of various solvents, selection of the emulsifying agents, as well as characterizing the mass transfer of hollow-fiber contactors.

Project Description

We are focusing on the inhibition of Propionibacteria (an anaerobe) by propionic acid and acetic acid. This system has a well characterized inhibition pathway and has been studied extensively as a model system for extractive fermentation. As time permits, we will investigate an aerobic culture of Escherichia coli which is often inhibited by the accumulation of acetic acid.

Supported emulsion liquid membranes (SELM) can be used in a microgravity environment for rejuvenation of spent media. The use of a hollow-fiber contactor avoids the mixing between the feed stream and the extracting phase while providing large contacting area for extraction. The use of an emulsion liquid membrane eliminates the equilibrium limitation of conventional liquid-liquid extraction and substantially improves the efficiency as well as the capacity of separation. In microgravity conditions, surfactant may not be required to stabilize the emulsion phase, greatly simplifying the downstream demulsification and product recovery processes. This provides a substantial reduction in energy and volume requirement of the unit. The design can be applied to separation of inhibitory compounds as well as products for fermentation processes. There is potential to extend the technique to other systems such as trace metal separations. The presence of stripping phase will sustain a high driving force for the extraction; thus, eliminating the

need for extractants which are likely to be toxic to the cells. All-in-all, the SELM system is ideally suited for this application.

Project Significance

Long-duration space flight will need methods for separation and purification of water for a variety of purposes including human consumption. In the more immediate future, NASA is planning to conduct a variety of cell culturing experiments in bioreactors aboard the International Space Station (ISS). These experiments will be a major consumer of water and power unless methods of media re-use are developed. The separation and purification techniques must make minimal demands on the spacecraft resources such as power, mass and volume. These goals are attainable with SELM extractive fermentations.

Project Outcomes

The results of work carried out during this project are summarized in two peer reviewed articles (attached) and the PhD Dissertation of Ms. Jin Li, who graduated from The University of Iowa Chemical & Biochemical Engineering program in May 2002. Her PhD is still being written as this report is being submitted but will be available from the PI after May 2002. The two peer reviewed articles are attached and the citations follow:

J. Li, S.Y. B. Hu and J.M. Wiencek, "*Development of a Supported Emulsion Liquid Membrane System for Propionic Acid Separation in a Microgravity Environment,*" *Biotechnology and Bioprocess Engineering* 6 426 (2001).

J.M. Wiencek and S.-Y. Hu, "*Emulsion Liquid Membrane Extraction in a Hollow-Fiber Contactor,*" *Chemical Engineering & Technology* 23 551 (2000).

In addition, another paper will be published soon in *The Journal of Colloid and Interface Science*:

Shih-Yao B. Hu, Jin Li, and John M. Wiencek, "*Feasibility of Surfactant-Free Supported Emulsion Liquid Membrane Extraction,*" submitted to *The Journal of Colloid and Interface Science* (in review).

This manuscript is also attached.

Presentations given related to this project are listed below:

S.Y. B. Hu (Speaker), J. Li, and J.M. Wiencek, "*Drop Coalescence in Hollow Fiber Membrane Modules in a Microgravity Environment,*" AICHE Annual Meeting, Indianapolis, IN (Nov. 2002).

J.Li (Speaker), S.Y.B. Hu, and J.M. Wiencek, "*Solvent Toxicity Issues in the Extraction of Propionic Acid from Propionibacteria Fermentation Media*," Biocatalysis, Evolution and Metabolic Engineering Conference, Iowa City, IA (Oct 2002).

S.Y. B. Hu (Speaker), J. Li, and J.M. Wiencek, "*The Development of a Supported Emulsion Liquid Membrane System for Propionic Acid Separation in a Microgravity Environment*," AIChE Annual Meeting, Reno, NV (Nov. 2001).

J.Li (Speaker), S.Y.B. Hu, and J.M. Wiencek, "*Supported Emulsion Liquid Membranes for Propionic Acid Recovery from Fermentation Media*," Center for Biocatalysis and Bioprocessing Annual Meeting, Iowa City, IA (Oct 2001).